Burt Lake Shoreline Survey 2009

By Tip of the Mitt Watershed Council

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SUMMARY

During the summer of 2009, the Tip of the Mitt Watershed Council conducted a comprehensive shoreline survey on Burt Lake that was sponsored by the Burt Lake Preservation Association. Watershed Council staff surveyed the entire shoreline in June and July to document conditions that potentially impact water quality. The parameters surveyed include: algae as a bio-indicator of nutrient pollution, greenbelt status, shoreline erosion, shoreline alterations, nearshore substrate types, and stream inlets and outlets. In September, select shoreline areas that lacked suitable substrate for algae growth were resurveyed with the Septic Leachate Detector (SLD).

Shoreline property management practices have the potential to negatively impact water quality in many ways. Nutrients are necessary to sustain a healthy aquatic ecosystem, but excess can adversely impact an aquatic ecosystem, and indirectly poses a danger to human health. Greenbelts provide many benefits to the lake ecosystem, which are lost when shoreline vegetation is removed. Erosion and shoreline alterations (seawalls, rip-rap, etc.) both have the potential to degrade water quality.

Survey results indicate that human activity along the Burt Lake shoreline is likely impacting the lake ecosystem and water quality. Some sign of nutrient pollution was noted at over half of shoreline properties, 36% had greenbelts in poor condition, 46% had altered shorelines, and erosion present at 6%. Relative to other lakes, Burt Lake had high percentages of parcels with *Cladophora* and a moderate number of poor greenbelts and altered shorelines. Properties with strong signs of nutrient pollution and those with poor greenbelts were scattered throughout the lake, but also clustered in certain locations.

In spite of indications of nutrient pollution occurring in nearshore areas, water quality data show decreasing nutrient concentrations. The water quality data does not necessarily reflect what is occurring in nearshore areas because it is collected far removed from the shoreline in open water. Furthermore, interpreting such data is confounded by the alteration of the lake's nutrient cycling caused by invasive zebra mussels. Regardless, changes should be made in shoreline property management to prevent degradation of lake water quality and to protect and improve the lake ecosystem.

To achieve the full value of this survey, the association should engage in follow-up activities, including: 1) Educate riparian property owners about preserving water quality and provide tips on what they can do to protect water quality; 2) Send a survey summary to all shoreline residents along with information about what each person can do to help; 3) Contact property owners confidentially to encourage them to participate in identifying and rectifying any problems that exist on their property; and 4) Organize an informational session to present survey results and best management practices that help protect and improve lake water quality. The shoreline survey should be repeated every 3-5 years as shoreline ownership, management, and conditions continually change.

INTRODUCTION

Background:

During the summer of 2009, a shoreline survey was conducted on Burt Lake by the Tip of the Mitt Watershed Council to document shoreline conditions that potentially impact water quality. The entire shoreline was surveyed to document the following: algae as a nutrient pollution indicator, erosion, shoreline alterations, greenbelts, and tributary inlets and outlets. This survey was funded by the Burt Lake Preservation Association.

The last shoreline survey performed on Burt Lake was carried out in 2001 and used for the development of the Burt Lake Watershed Management Plan (TOMWC, 2002). Based on the 2001 shoreline survey report, indicators of nutrient pollution were found at 20% of the 972 properties surveyed and poor greenbelts were documented at 56% of properties (TOWMC, 2001). The 2001 shore survey report also references a partial shoreline survey conducted on Burt Lake in 1988, though no report was found was found in the Tip of the Mitt Watershed Council's library.

The 2008 survey provides another comprehensive data set documenting shoreline conditions on Burt Lake; a valuable data set that can be used as a lake management tool. Combined with follow-up activities, such as questionnaires and on-site visits, problems in shoreline areas that threaten the lake's water quality can be identified and solved. These solutions are often simple and low cost, such as regular septic system maintenance, proper lawn care practices, and wise land use along the shoreline. Prevention of problem situations can also be achieved through the publicity and education associated with the survey. Periodic repetition of shoreline surveys is important for identifying new and chronic problem sites, determining long-term trends of near-shore nutrient inputs and shoreline alterations associated with land-use changes, and for assessing the success of remedial actions.

Shoreline development impacts:

Lake shorelines are the critical interface between land and water; where human activity has the greatest potential for degrading water quality. Developing shoreline properties for residential, commercial or other uses invariably has impacts on the aquatic ecosystem. During the development process, the natural landscape is altered in a variety of ways; vegetation is removed, the terrain is graded, utilities installed, structures are built, and areas are paved. These changes to the landscape and subsequent human activity in the shoreline area have consequences on the aquatic ecosystem. Nutrients from wastes, contaminants from cars and roads, and soils from eroded areas are among some of the pollutants that end up in and impact the lake following shoreline development.

Nutrient pollution can have adverse impacts on aquatic ecosystems and indirectly poses a danger to human health. Nutrients are necessary to sustain a healthy aquatic ecosystem, but excess will stimulate unnatural plant growth. Increased abundance of aquatic macrophytes (higher or vascular plants) can become a nuisance to recreation in shallow areas (typically less than 20 feet of depth). An increase in algal blooms also has the potential to become a recreational nuisance when algal mats and scum are formed on the lake's surface. Additionally, algal blooms pose a public health risk as some species produce toxins, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system).

Excess growth of both macrophytes and algae has the potential to degrade water quality by depleting the ecosystem's dissolved oxygen stores. During nighttime respiration, plants compete with other organisms for a limited oxygen supply. Furthermore, the decomposition of dead algae and plant material has the potential to deplete dissolved oxygen supplies due to the aerobic activity of decomposers, particularly in the deeper waters of stratified lakes.

In general, large, deep lakes such as Burt are less sensitive to nutrient pollution. Large lakes with greater water volume have a bigger buffer and thus, greater resistance to nutrient pollution. The large lakes tend to have greater dissolved oxygen stores and the greater volume allows for greater dilution of nutrients. By contrast, small lakes generally have smaller stores of dissolved oxygen, a lesser ability to dilute nutrients and therefore, are more susceptible to the indirect impacts of nutrient pollution. Small lakes with extensive shallow areas are at even greater risk as there are more habitats to support excessive aquatic macrophyte growth. Burt Lake is one of the largest inland lakes in the State of Michigan (17,400 acres, maximum depth = 72 feet) and thus, relatively resilient to nutrient pollution. Additionally, Burt Lake is a drainage lake with inflows and an outflow, which provides a mechanism to flush excess nutrients out of the system. In spite of Burt Lake's resilience to nutrient pollution, unnaturally high nutrient concentrations can occur and cause problems in localized areas, particularly near sources in shoreline areas.

Surface waters receive nutrients through a variety of natural and cultural (human) sources. Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff, organic inputs from the riparian (shoreline) area and atmospheric deposition. Springs, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter and wetland seepages may discharge nutrients at certain times of the year. Cultural sources include septic and sewer systems, fertilizer application, and stormwater runoff from roads, driveways, parking lots, roofs, and other impervious surfaces. Poor agricultural practices, soil erosion, and wetland destruction also contribute to nutrient pollution. Furthermore, some cultural sources (e.g., malfunctioning septic systems and animal wastes) pose a potential health risk due to bacterial and viral contamination.

Severe nutrient pollution is detectable through chemical analyses of water samples, physical water measurements, and the utilization of biological indicators (a.k.a., bio-indicators). Chemical analyses of water samples to check for nutrient pollution can be effective, though costlier and more labor intensive than other methods. Typically, samples are analyzed to determine nutrient concentrations (usually forms of phosphorus and nitrogen), but other chemical constituent concentrations can be measured, such as chloride, which are related to human activity and often elevated in areas impacted by malfunctioning septic or sewer systems. Physical measurements are primarily used to detect malfunctioning septic and sewer systems, which can cause localized increases in water temperature and conductivity (i.e., the water's ability to conduct an electric current). Biologically, nutrient pollution can be detected along the lake shore by noting the presence of *Cladophora* algae.

Cladophora is a branched, filamentous green algal species that occurs naturally in small amounts in northern Michigan lakes. Its occurrence is governed by specific environmental requirements for temperature, substrate, nutrients, and other factors. It is found most commonly in the wave splash zone and shallow shoreline areas of lakes, and can also be found in streams. It grows best on stable substrates such as rocks and logs, though artificial substrates such as concrete or wood seawalls are also suitable. *Cladophora* prefers water temperatures in a range of 50 to 70 degrees Fahrenheit, which means that the optimal time for its growth and thus, detection, in northern Michigan lakes is from late May to early July and from September to October.

The nutrient requirements for *Cladophora* to achieve large, dense growths are typically greater than the nutrient availability in the lakes of Northern Michigan. Therefore, shoreline locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake can be identified by noting the presence of *Cladophora*. Although the size of the growth on an individual basis is important in helping to interpret the cause of the growth, growth features of *Cladophora* are greatly influenced by such factors as current patterns, shoreline topography, size and distribution of substrate, and the amount of wave action the shoreline is subject to. Therefore, the description has limited value when making year to year comparisons at a single location or estimating the relative amount of shoreline nutrient inputs. Rather, the presence or absence of any significant growth at a single site over several years is the most valuable comparison. It can reveal the existence of chronic nutrient loading problems, help interpret the cause of the problems, and assess the effectiveness of any remedial actions. Comparisons of the total number of algal growths can reveal trends in nutrient input due to changing land use.

Erosion along the shoreline has the potential to degrade the lake's water quality. Stormwater runoff through eroded areas carries sediments into the lake and impacts the lake ecosystem in a variety of ways. Sediments clog the gills of fish, aquatic insects and other aquatic organisms. Excessive sediments smother fish spawning beds and fill interstitial spaces that provide habitat for a variety of aquatic organisms. While moving through the water column, sediments absorb sunlight energy and increase water temperatures. In addition, nutrients adhere to sediments that wash in from eroded areas, which can lead to nuisance aquatic plant growth and large algae blooms.

Shoreline greenbelts are essential for maintaining a healthy aquatic ecosystem. A greenbelt consisting of a variety of native woody and herbaceous plant species provides habitat for near-shore aquatic organisms as well as terrestrial animals. Greenbelts function as erosion control devices, stabilizing the shoreline with plant root structures that protect against wave action and ice. The canopy of the greenbelt provides shade to near-shore areas, which is particularly important for lakes with cold-water fisheries. In addition, greenbelts provide a mechanism to reduce overland surface flow and absorb pollutants carried by stormwater from rain events and snowmelt.

Tributaries have great potential for influencing a lake's water quality as they are one of the primary conduits through which water is delivered to a lake from its watershed. Inlet streams may provide exceptionally high quality waters that benefit the lake ecosystem, but conversely have the potential to deliver polluted waters that degrade the lake's water quality. Outlet streams flush water out of the lake, providing the means to remove contaminants that have accumulated in the lake ecosystem. With regards to shore surveys, noting the location of inlet tributaries is very helpful when evaluating shoreline algae conditions because nutrient concentrations are generally higher in streams than in lakes. The relatively higher nutrient levels delivered from streams often lead to naturally heavier *Cladophora* and other algae growth along the shoreline.

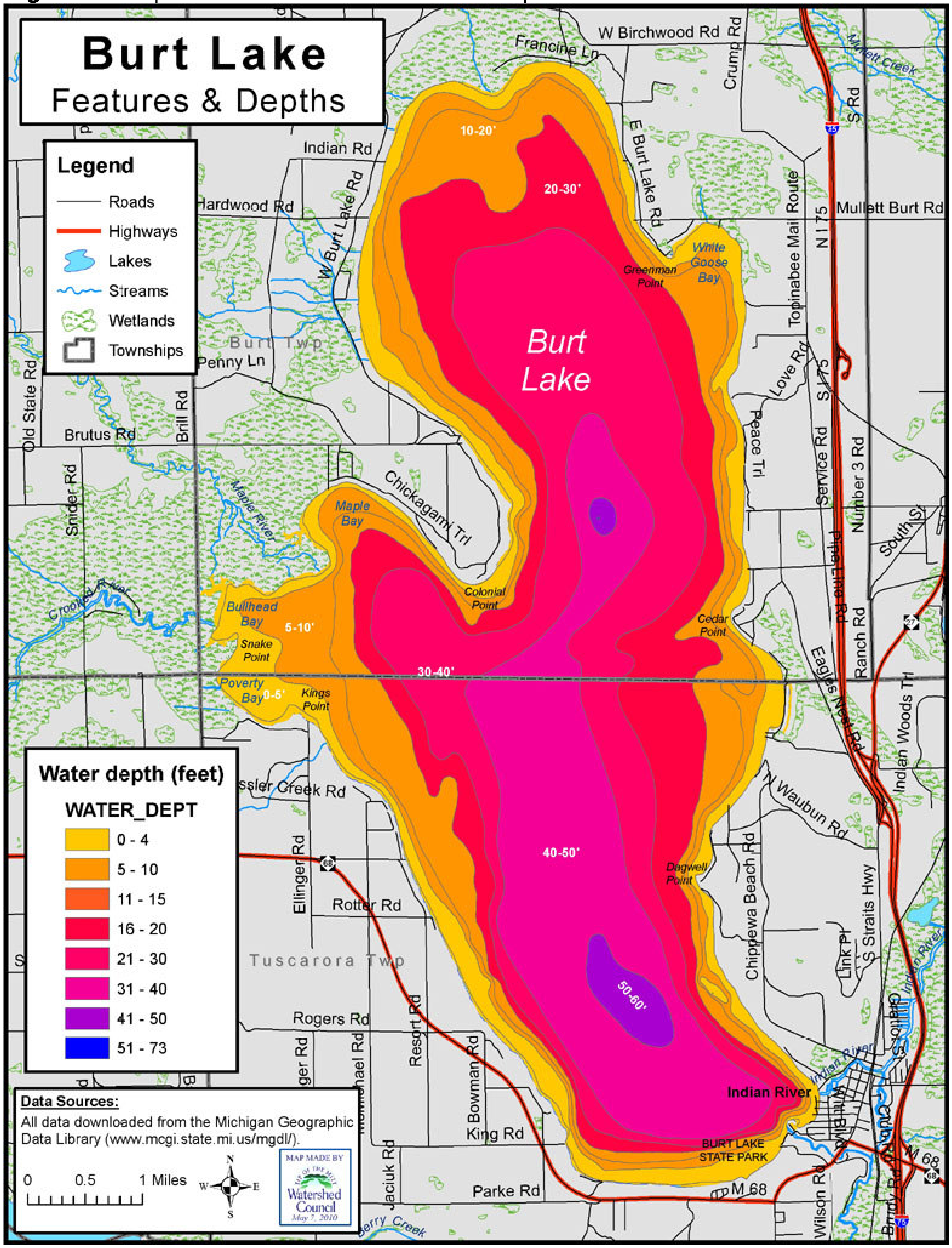
Responsible, low-impact, lake shoreline property management is paramount for protecting water quality. Maintaining a healthy greenbelt, regular septic tank pumping, treating stormwater with rain gardens, addressing erosion sites, and eliminating fertilizer, herbicide, and pesticide application are among many low-cost best management practices that minimize the impact of shoreline properties on lake water quality. Responsible stewardship on the part of shoreline property owners and living in harmony with the lake is vitally important for sustaining a healthy and thriving lake ecosystem.

Study area:

Burt Lake is located in the northern tip of the Lower Peninsula of Michigan; in Burt and Tuscarora Townships of east-central Cheboygan County. Based on digitization of aerial orthophotography provided by Cheboygan County Equalization (2008), the shoreline of Burt Lake measures 35.07 miles and lake surface area totals 17,436 acres. Burt Lake is approximately 9.5 miles long and nearly 5 miles across at its widest point. A prominent lobe called Colonial Point extends out from the west shore toward the middle of the lake, to the south of which lie Maple, Bullhead, and Poverty Bays (Figure 1). In the northeast corner, Greenman Point extends southward, sheltering White Goose Bay to the east. Bathymetry maps from the State of Michigan show the deepest area located directly out from Colonial Point with a maximum depth of 73 feet. Tip of the Mitt Watershed Council water quality monitoring data have confirmed this maximum depth. According to digitized bathymetry maps acquired from the Michigan Geographic Data Library, approximately 64% of the lake exceeds 20 feet of depth. Broad shallow plateaus are found on the west central side between Maple and Poverty Bays as well as in the north end of the lake.

Burt Lake is a drainage lake with water flowing into and out of the lake.

Figure 1. Map of Burt Lake: Features and Depths



The primary inlets include the Maple and Crooked Rivers to the west, the Sturgeon River in the southeast corner and Carp Creek in the north end (USGS, 1990). The only outlet is the Indian River in the southeast corner. Extensive wetland areas are located adjacent to the lake between Maple and Poverty Bays on the west-central shoreline and at the northern end of the lake.

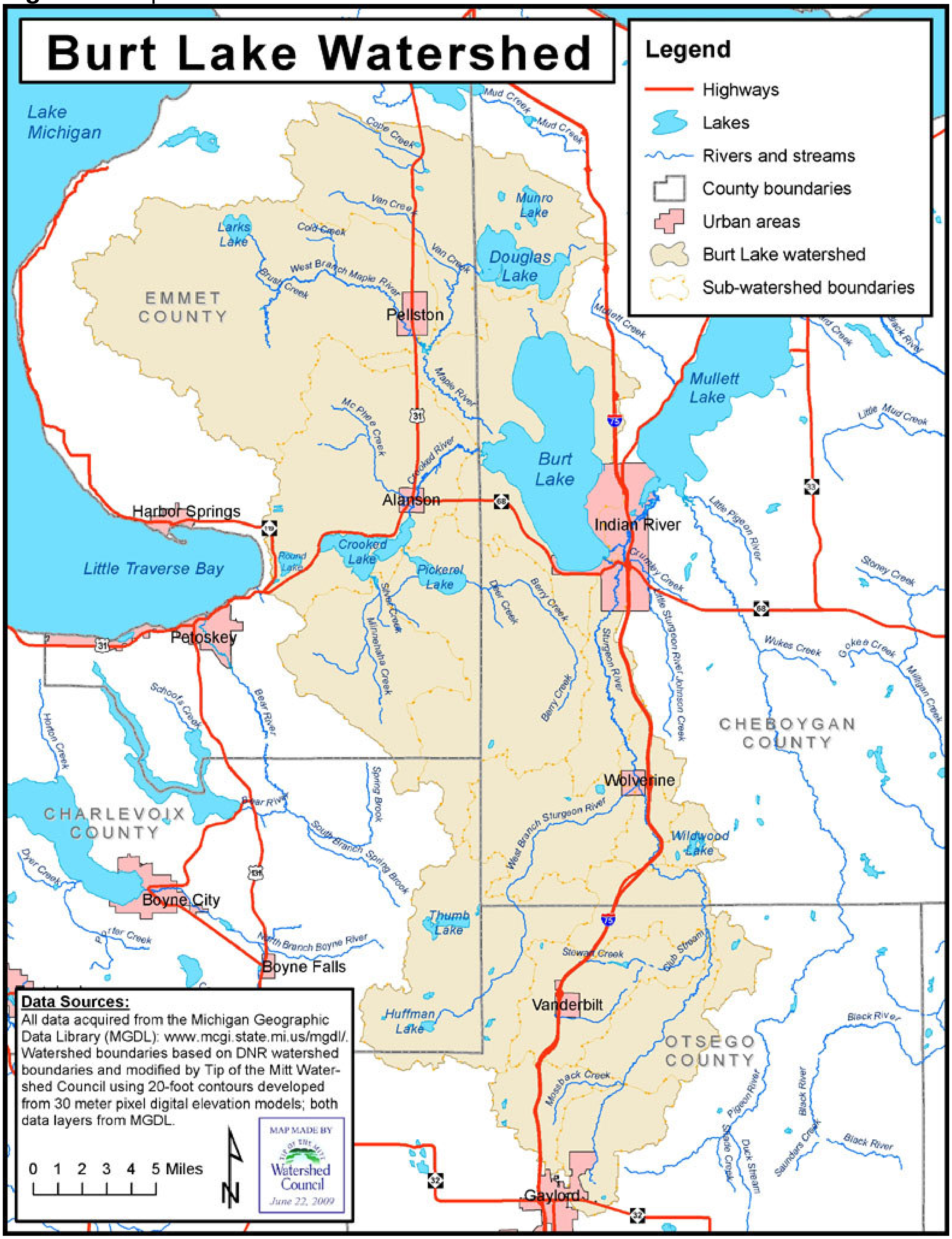
Using and elevation data acquired from the State of Michigan, Watershed Council staff developed watershed boundary files for Burt Lake in a GIS (Geographical Information System). Based on these data, the Burt Lake watershed encompasses approximately 371,173 acres of land and water. The watershed stretches from the City of Gaylord in the south to the village of Levering to the north and contains a number of other regionally important water bodies including Crooked, Douglas, Larks, Munro, Pickerel, and Round Lakes (Figure 2). A watershed ratio of 20.29 was calculated by dividing the lake surface area into the watershed area (not including the lake), indicating that there are over 20 acres of watershed area for each acre of Burt Lake water surface area. This ratio provides a statistic for gauging susceptibility of lake water quality to changes in watershed land cover. Relative to other lakes in Northern Michigan, Burt Lake has a high watershed ratio and therefore, a strong buffer to protect the lake from impacts associated with watershed development.

Land cover statistics were generated for the watershed using remote sensing data from the Coastal Great Lakes Land Cover project (Table 1). Based on 2006 data, the majority of the watershed's landcover is natural; consisting

Table 1. Burt Lake watershed land-cover statistics.

Land Cover Type	2000 Acreage	2000 Percent	2006 Acreage	2006 Percent	Change (%)
Agriculture	31374.86	8.45	33904.15	9.13	0.68
Barren	929.78	0.25	671.65	0.18	-0.07
Forested	186825.07	50.30	193792.82	52.18	1.88
Grassland	55628.32	14.98	35674.85	9.61	-5.37
Scrub/shrub	11600.79	3.13	14106.14	3.80	0.67
Urban	9278.47	2.50	13546.24	3.65	1.15
Water	28320.59	7.63	27980.16	7.53	-0.09
Wetland	47409.78	12.77	51713.13	13.92	1.16
TOTAL	371367.66	100.00	371389.15	100.00	NA

Figure 2. Map of the Burt Lake Watershed.

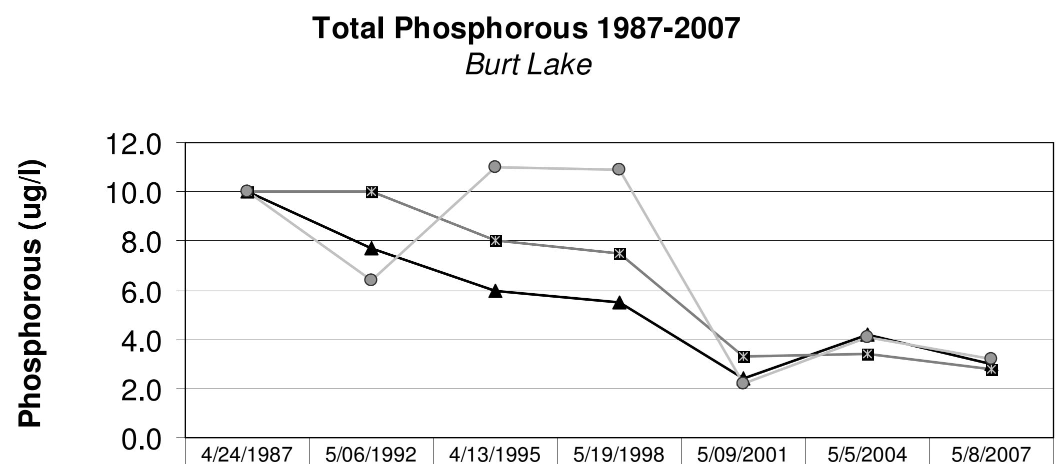


primarily of forest, wetlands, and grassland. There is relatively little agricultural landcover in the watershed (~9%) and even less urban (~3.7%). However, both of these land-cover types increased by approximately one percent between 2000 and 2006.

The water quality of Burt Lake has been monitored consistently for more than two decades. The Burt Lake Preservation Association has actively supported water quality monitoring programs on Burt Lake, providing volunteers for monitoring programs coordinated by the Watershed Council. In addition, Burt Lake is monitored by Watershed Council staff as part of the Comprehensive Water Quality Monitoring program (CWQM). Watershed Council databases contain Volunteer Lake Monitoring and CWQM data that date back to 1989 and 1987 respectively.

Data collected through these programs indicate that water quality remains high. Total phosphorus data collected in the CWQM program show that levels have dropped considerably throughout the last 20 years and are now consistently below 10 parts per billion (PPB), which is typical for high quality lakes of Northern Michigan (Figure 3). Based on volunteer lake monitoring data, Burt Lake falls into the oligotrophic category, which indicates low biological productivity (Figure 4). Oligotrophic lakes are characteristically large, deep, and nutrient poor, but have ample stores of dissolved oxygen and, in general, high water quality.

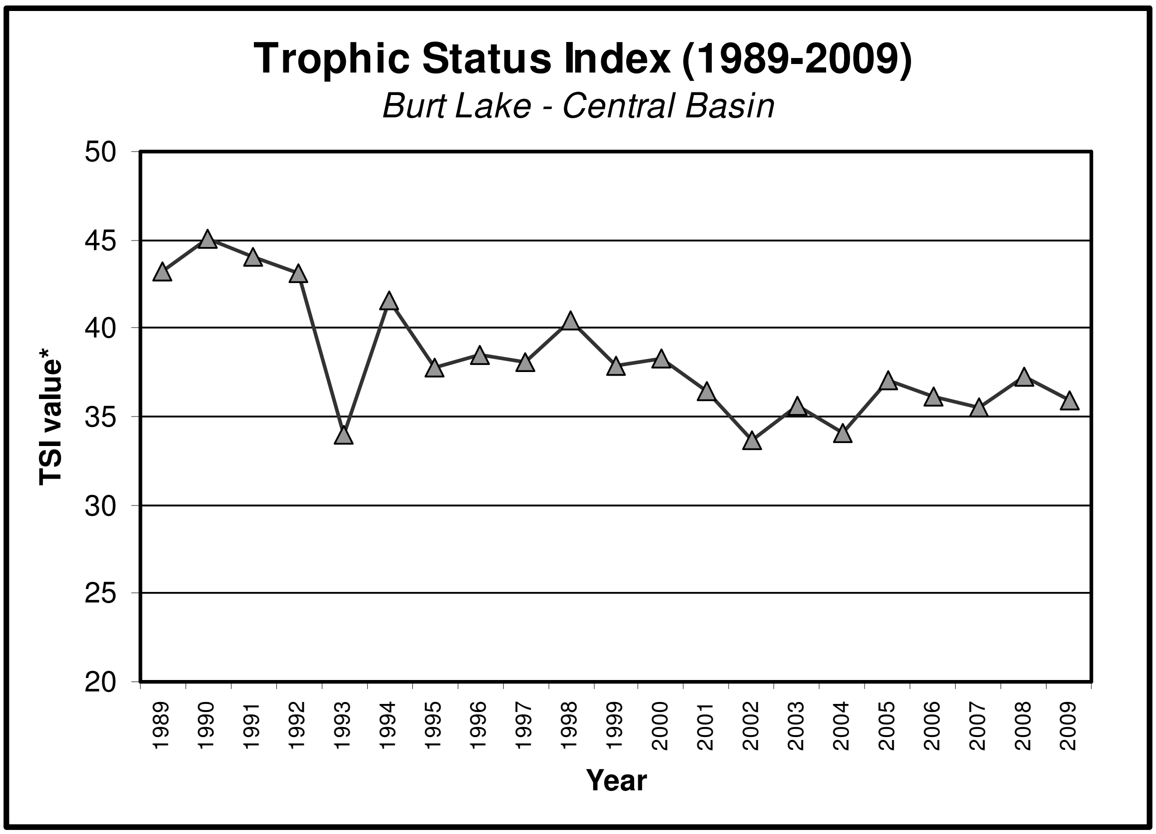
Figure 3. Chart of phosphorus data from Burt Lake



	4/24/1987	5/06/1992	4/13/1995	5/19/1998	5/09/2001	5/5/2004	5/8/2007
Surface	10.0	7.7	6.0	5.5	2.4	4.2	3.0
Middle	10.0	10.0	8.0	7.5	3.3	3.4	2.8
Bottom	10.0	6.4	11.0	10.9	2.2	4.1	3.2

**Total phosphorus measured in ug/l, which is milligrams per liter or parts per billion.*

Figure 4. Chart of trophic status index data from Burt Lake.



**Trophic Status Index values based on annual averaged Secchi disc depth data and represent the trophic status (biological productivity) of the lake: 0-38 = oligotrophic (low productive system), 39-49 = mesotrophic (moderately productive system), and 50+ = eutrophic (highly productive system).*

METHODS

The Burt Lake shoreline survey was carried out from June to September of 2009 in two distinct phases. From June through July, the entire Burt Lake shoreline was surveyed to comprehensively document shoreline conditions. In September, select shoreline areas were surveyed a second time to collect Septic Leachate Detector (SLD) data.

During the first phase of fieldwork, Watershed Council staff and interns surveyed the shoreline, noting and photographing property features on all shoreline parcels. Shoreline conditions were surveyed by traveling in kayak as close to the shoreline as possible (usually within 20 feet) and noting *Cladophora* growth, substrate type, erosion, greenbelt length, greenbelt depth, shoreline alterations, and tributaries. A GPS camera was used to photograph all shoreline properties. All information was recorded on field data sheets, subsequently inputted into a database, and used in conjunction with GPS data to link field data and photographs with property owner (equalization) data.

During the second phase of fieldwork, Watershed Council staff resurveyed shoreline areas that did not have suitable substrate for Cladophora growth. These shoreline areas, which were noted as having sandy or mucky substrate during the first pass, were surveyed again in the fall using the SLD to detect nutrient pollution from malfunctioning septic systems.

Field Survey Parameters

Shoreline property features were documented by photographing and noting physical features on a data sheet, such as building descriptions, public access sites, and county road endings. Due to data sheet space limits, building descriptions were recorded in an abbreviated cryptic style. For example, *Red 2 sty, brn rf, wht trm, fldstn chim, lg pine* means that the property has a red two-story house with a brown roof, white trim, fieldstone chimney, and a large pine tree in the yard. Whenever possible, names of property owners and addresses were included.

Developed parcels were noted on field data sheets and included as a separate column in the database. Properties described as developed indicate the presence of buildings or other significant permanent structures, including roadways, boat launching sites, and recreational properties (such as parks with pavilions and parking lots). Properties with only mowed or cleared areas, seasonal structures (such as docks or travel trailers), or unpaved pathways were not considered developed. Additionally, large parcels that had structures in an area far from the water's edge were not considered developed. The length and area of developed versus undeveloped shoreline was not calculated.

Many species of filamentous green algae are commonly found growing in the nearshore regions of lakes. Positive identification of these species usually requires the aid of a microscope. However, *Cladophora* usually has an appearance and texture that is quite distinct to a trained surveyor, and these were the sole criteria upon which identification was based. Other species of filamentous green algae can respond to an external nutrient source in much the same way as *Cladophora*, though their value as an indicator species is not thought to be as reliable. When other species occurred in especially noticeable, large, dense growths, they were recorded on the data sheets and described the same as those of *Cladophora*.

When *Cladophora* was observed, it was described in terms of the length of shoreline with growth, the relative growth density, and any observed shoreline features potentially contributing to the growth. For example, "MHx30 – seeps" denotes a moderate to heavy growth that covered 30' of the shoreline and with groundwater seeps in the area that may have been contributing to the growth. Both shoreline length and growth density are subjective estimates. Growth density is determined by estimating the percentage of substrate covered with *Cladophora* using the following categorization system:

Table 2. Categorization system for *Cladophora* density.

Density Category	**Field Notation**	**Substrate Coverage**
Very Light	(VL)	0% *
Light	(L)	1- 20%
Light to Moderate	(LM)	21-40%
Moderate	(M)	41-60%
Moderate to Heavy	(MH)	61-80%
Heavy	(H)	81-99%
Very Heavy	(VH)	90-100% *

**Very Light is noted when a green shimmer is noticed on hard substrate, but no filamentous growth present. Very Heavy overlaps with heavy and is distinguished by both high percentage of substrate coverage and long filamentous growth.*

Among other things, the distribution and size of each *Cladophora* growth is dependent on the amount of suitable substrate present. The extent of suitable substrate should therefore be taken into account when interpreting the occurrence of individual growths, and assessing the overall distribution of *Cladophora* along a particular stretch of shoreline. Substrate types were noted during the survey, using the following abbreviations: m = soft muck or marl, s = sand, g = gravel (0.1” to 2.5” diameter), r = rock (2.5” to 10” diameter), b = boulder (>10” diameter), and w = woody debris. Substrate suitable for *Cladophora* growth include the g, r, b, and w types. The extent of suitable substrate along a shoreline parcel in terms of distance was not documented.

To fill gaps in the data, the Septic Leachate Detector (SLD) was used during a second pass to detect nutrient pollution in shoreline areas lacking suitable substrate for Cladophora growth. The SLD focuses specifically on nutrient pollution caused by malfunctioning septic systems that leach into and contaminate nearshore shallow groundwater layers that eventually seep into the lake. The SLD consists of a water pumping system that provides continuous flow to a chamber where the conductivity of the water is measured. Using the SLD, water was pumped from as close to the shoreline as possible (usually within 1-2 feet) and conductivity levels were continually monitored to note changes. Any increases or decreases were noted on data sheets. The SLD portion of the survey was carried out in early autumn; when signals are typically strongest following generally heavier septic system use during the summer by lakeshore residents.

Erosion was noted based on shoreline areas that exhibited: areas of bare soil, leaning or downed trees, exposed tree roots, undercut banks, slumping hunks of sod, excessive deposits of sediments, or muddy water. Similar to *Cladophora*, shoreline erosion was recorded on field data sheets with estimates of its extent and relative severity (light, moderate, or heavy/severe). For example "Mx20" indicated 20 feet of shoreline with moderate erosion. Additional information about the nature of the erosion, such as potential causes, were also noted.

Greenbelts, i.e. shoreline vegetation, were rated based on the length of shoreline with a greenbelt and the average depth of the greenbelt from the waters edge landward into the property. Ratings for length ranged from zero to four while depth ranged from zero to three and were based on the following:

Length	0: None, 1: 1-10%, 2: 10-25%, 3: 25-75%, 4: >75%
Depth	0: None, 1: <10 ft, 2: 10-40 ft, 3: >40 ft

Greenbelt ratings for length and depth were summed to produce an overall greenbelt score. Greenbelt scores ranged from 0 to 7, representing the greenbelt status or health. Scores of 0 were considered very poor, 1-2: poor, 3-4: moderate, 5-6: good, and 7: excellent.

Shoreline alterations were surveyed and noted with the following abbreviated descriptions:

SB = steel bulkhead (i.e., seawall)	BB = boulder bulkhead
CB = concrete bulkhead	RR = rock rip-rap
WB = wood bulkhead	BS = beach sand
BH = permanent boathouse	DP = discharge pipe

Abbreviations were sometimes mixed or vary from what is listed above.

Tributaries (i.e., rivers and streams) were noted on the field data sheets and included in a separate column in the database. Additional information regarding shoreline property features or shoreline conditions recorded on field data sheets was included in the database in a “comments” column.

Data Processing

Upon completing field work, all field data were transferred to computer. Information from field data sheets was inputted into a Microsoft Excel® workbook. Digital photographs and GPS data were uploaded to a computer at the Watershed Council office and processed for use.

Linking field and equalization data allows shoreline conditions documented during the survey to be referenced by parcel identification number or parcel owner name. Field data were linked to Cheboygan County parcel data in a GIS with the aid of GPS and photographs. Errors can occur wherein field data are not linked to the appropriate parcel.

In order to display survey results without pinpointing specific parcels, a new map layer was developed using the parcel map data layer acquired from the County Equalization department and a Burt Lake shoreline layer. The new map layer consists of a narrow band following the shoreline, split into polygons that contain field and equalization data. This data layer was overlaid with other GIS data from the State of Michigan to produce maps to display survey results.

Final products include a comprehensive database, a complete set of GPS digital photographs, GIS data layers of shoreline parcels that include both county equalization and shore survey data, and a map displaying results. The shoreline survey database contains a sequential listing of properties beginning at the Maple Bay State Park boat launch and traveling counter-clockwise around the entire perimeter of the lake. The database contains all data collected in the field and identification numbers in the database correspond to those in the GIS data layer and on hard-copy maps. GPS photographs were renamed using the same identification numbers and are linked to a GIS data layer.

RESULTS

This survey documented shoreline conditions at 1123 parcels on Burt Lake. The length of shoreline per parcel varied from less than 20 feet to more than a mile. The SLD was used along the shoreline of 248 parcels.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline of 932 properties (83%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline of 527 parcels (47% of the total or 57% of properties with suitable habitat). At properties where *Cladophora* growth was observed, nearly 30% consisted of heavy or very heavy growth whereas just under 25% of parcels had growth in the light or very light categories (Table 3).

Table 3. *Cladophora* density statistics.

***Cladophora* Density**	**Parcels**	**Percent**
Very light	14	2.66
Light	113	21.44
Light to Moderate	76	14.42
Moderate	117	22.20
Moderate to Heavy	56	10.63
Heavy	78	14.80
Very Heavy	73	13.85
TOTAL	527	100.00

In shoreline areas lacking suitable substrate for Cladophora growth, the majority of SLD readings showed a weak signal (Table 4). Strong signals of potential septic leachate pollution were only found at 15% of properties surveyed. SLD signals were particularly strong in front of Burt Lake State Park.

Table 4. Septic Leachate Detector (SLD) results.

SLD Rating	Number	Percent
Weak	119	47.79
Moderate	91	36.55
Strong	38	15.26
TOTAL	248	100.00

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Nearly half (44%) of greenbelts along the Burt Lake shoreline were found to be in good or excellent condition (Table 5). However, over a third of the shoreline properties (36%) received a greenbelt rating in the poor or very poor categories.

Table 5. Greenbelt score statistics.

Greenbelt Score/Rating	Number of Parcels	Percent of Parcels
0 = Very Poor (absent)	151	13.45
1-2 = Poor	253	22.53
3-4 = Moderate	226	20.12
5-6 = Good	285	25.38
7 = Excellent	208	18.52

Some form of shoreline alteration was noted at 46% of shoreline properties (Table 5). The majority consisted of riprap (48%) while seawalls accounted for nearly 30% of documented alterations.

Table 6. Shoreline alteration statistics.

Alteration Type	Number of Parcels	Percent of Parcels
Riprap (small)	170	32.95
Riprap (boulder)	80	15.50
Seawalls	151	29.26
Mixed	73	14.15
Other*	42	8.14
TOTAL	516	100.00

**other includes rock groins, boat ramps, boat houses, and beach sand.*

Erosion was noted along the shoreline at 68 parcels (6%). The severity of documented erosion was somewhat equally divided between categories with 32% light, 40% moderate, and 28% heavy.

Tributaries (e.g., rivers, streams) were documented at 109 properties. The actual number is likely lower because tributaries located between land parcels were tallied for both properties.

A map was developed to display and examine clusters and patterns in the occurrence of heavy *Cladophora* growths, strong SLD signals, and poor greenbelts on the Burt Lake shoreline. There was an extensive area of relatively contiguous parcels with heavy *Cladophora* growth along the southwest shoreline of the lake extending from King Road north nearly to Kings Point. Areas of heavy *Cladophora* growth, as well as strong SLD signals, were also noted in the northwest side of the lake in an area spanning the shoreline from Mundt Road to Indian Road. On the east side of the lake, nutrient pollution indicators were not as clustered, though there were some groupings in the White Goose Bay area, toward the middle of the lake north of Cedar Point, and scattered throughout an area extending from Indian River to the north of Dagwell Point.

Poor greenbelts were clustered in multiple areas of the lake. On the west side, poor greenbelts were found in an extensive area between Mundt and Indian Roads, but also found in smaller clusters in Maple and Poverty Bays. On the east side, poor greenbelts were documented on many properties in the White Goose Bay area extending to the north, to the north of Cedar Point, in the canal area to the south of Cedar Point, and in the southeast corner of the lake from the Indian River outlet to the west past Burt Lake State Park.

DISCUSSION

Results from the 2009 shoreline survey indicate that nutrient pollution, poor greenbelts, and shoreline alterations pose a threat to the water quality and overall health of Burt Lake. Nutrient pollution indicators were documented on over half of the shoreline properties (includes SLD data), over a third of greenbelts were in poor condition, and nearly half of the properties had altered shorelines. Shoreline erosion, however, was very limited.

Comparisons with 2001 shoreline survey results show that there have been considerable changes in terms of the number of properties with documented Cladophora growth and those with poor greenbelts. With regards to Cladophora, there was a drastic increase between 2001 and 2009 with the number of properties more than doubling from 20% to 47% (Table 7). Conversely, the number of properties with poor greenbelts dropped by nearly half; from 56% of properties in 2001 to 36% in 2009 (Table 8).

Table 7. *Cladophora* density comparisons: 2001 to 2009.

***Cladophora* Density**	**2001 Parcels**	**2001 Percent**	**2009 Parcels**	**2009 Percent**
None	780	80.08	596	53.07
Very light	4	0.41	14	1.25
Light	124	12.73	113	10.06
Light to Moderate	35	3.59	76	6.77
Moderate	25	2.57	117	10.42
Moderate to Heavy*	0	0.00	56	4.99
Heavy	5	0.51	78	6.95
Very Heavy	1	0.10	73	6.50
TOTAL**	974	100.00	1123	100.00

**Note that the "Moderate to Heavy" category was not used in the 2001 survey.*
***The total number of parcels varied between surveys due to the application of GPS and GIS in the 2009 survey.*

Table 8. Greenbelt rating comparisons: 2001 to 2009.

Greenbelt Rating	**2001 Percent**	**2009 Percent**
Poor	56.00	35.98
Moderate	23.00	20.12
Good	21.00	43.90

Clearly, shoreline property owners improved their land management practices and made great strides in improving the health of greenbelts on the Burt Lake shoreline. This is likely due, at least in part, to the initiative of the Burt Lake Preservation Association and subsequent collaborative efforts with Tip of the Mitt Watershed Council to address the greenbelt problem documented in the 2001 survey through the "Restore the Shore" campaign. However, there are now strong indications that nutrient pollution around the lake is increasing and in need of attention.

Relative to shore surveys conducted on other lakes in the region, Burt Lake had relatively high percentages of shoreline parcels with *Cladophora* growth and a moderately high percentage of heavy growth (Table 5). Burt Lake falls somewhere in the middle of the range in terms of the number of properties with poor greenbelts, though currently greenbelt data are limited to five lakes. Although nearly half of properties on Burt Lake had altered shorelines, the percentage is not atypical for lakes surveyed in this area.

Table 9. Shore survey statistics from Northern Michigan lakes.

Lake Name	Survey Date	Cladophora*	Heavy Algae*	Erosion*	Greenbelts*	Alterations*
Black Lake	2005	20%	21%	ND	ND	ND
Burt Lake	2009	47%	29%	6%	36%	46%
Huffman Lake	2006	60%	22%	ND	ND	76%
Charlevoix	2007	17%	20%	9%	30%	61%
Larks Lake	2006	4%	0%	ND	12%	29%
Mullett Lake	2008	59%	50%	12%	64%	58%
Sixmile Lake	2008	14%	5%	11%	34%	30%
Thumb Lake	2007	4%	0%	ND	ND	39%
Walloon Lake	2005	36%	15%	1%	ND	68%

**Percentages are in relation to number of parcels on the lake shore, except for "heavy algae", which is the percent of parcels with Cladophora growth. Greenbelt percentage reflects the percentage of parcels with greenbelts in poor condition. ND=no data.*

In spite of the problems exposed by this survey, the water quality of Burt Lake remains high. Due to its oligotrophic (nutrient poor) nature and the high volume of water flushing through it as a drainage lake, Burt Lake is quite resilient to nutrient pollution. However, such resiliency is not without limits. To prevent potentially serious and irreversible changes to the lake ecosystem, changes need to be made in shoreline property management. Mismanagement of shoreline properties can degrade the lake's water quality, diminish fisheries, and even create an environment that poses threats to human health.

Development of shoreline parcels negatively impacts a lake's water quality due to a multitude of factors. Among the most serious impacts are: 1) loss of vegetation that would otherwise absorb and filter pollutants in stormwater runoff as well as stabilize shoreline areas and prevent erosion, 2) increased impervious surface area such as roofs, driveways and roads, which leads to greater inputs of stormwater runoff and associated pollutants, and 3) waste and byproducts of human activity such as septic leachate, fertilizers and decomposing yard waste that potentially reach and contaminate the lake water. Clearly, there are many problems associated with development, but there are also many solutions for reducing or even entirely eliminating impacts.

Numerous best management practices have been developed that help minimize negative impacts to water quality and which can be utilized during, or retroactively after, the development of shoreline parcels. A buffer of diverse, native plants can be maintained along the shoreline to filter pollutants and reduce erosion. Impacts from stormwater generated from roofs, roads, and driveways can be reduced using rain barrels, rain gardens, grassy swales, and many other techniques. Leachate reaching the lake from septic systems can be minimized by pumping the septic tank regularly, having all components of the septic system inspected regularly and replacing the septic system when necessary. Mulch can be composted far from the shoreline and fertilizers applied sparingly if at all.

Of the shoreline areas showing evidence of potential nutrient pollution, some of the algae growth is undoubtedly associated with septic system leachate or other factors associated with development and human activities, but others are probably due to natural factors. There are numerous streams, springs and seeps flowing into Burt Lake at different points along the shoreline that may be delivering nutrients that naturally increase algal growth. Where human-caused nutrient pollution is occurring, the source has to be identified in order to address the problem. Although impeded by factors such as wind, wave action, currents, and groundwater paths, efforts by trained personnel to identify specific nutrient input sources on individual properties are often successful.

Water quality monitoring data from Burt Lake do not show an increase in nutrient concentrations, though these data may not reflect what is occurring in nearshore areas. Contrary to what one might expect based on shoreline survey results, phosphorus and nitrogen levels have decreased in Burt Lake during the last few decades (TOMWC, 2007). In addition, water clarity has increased and algal biomass has decreased (TOMWC, 2009). These data seem to indicate a decrease in nutrient pollution, but there are a few things to consider when interpreting such data. One is that all such data have been collected out in open water, far removed from shoreline areas where the majority of nutrient pollution tends to occur. Perhaps of greater importance, zebra mussels have altered the lake ecosystem, disrupted natural nutrient cycling, and probably caused the documented decrease in nutrient concentrations and algal biomass as well as the increase in water clarity.

The shoreline vegetation in Burt Lake is in much better shape than in 2001, but the lake ecosystem would benefit from further improvements. Greenbelts continue to be in poor condition throughout much of the lake, with over a third of properties possessing little to no vegetation beyond turf grass. The lack of vegetation on the lake shoreline, which provides habitat and food source, impacts aquatic fauna ranging from minute crustaceans to top predator fish. Furthermore, the absence of vegetation leads to greater amounts of shoreline erosion and less filtration of pollutants. Although a substantial number of greenbelts are in poor condition, nearly 20% of properties received a perfect score, indicating exemplary greenbelt health. Properties with healthy, intact greenbelts provide a model for improvement for other shoreline properties. Further improvement of the quality of greenbelts throughout the shoreline would invariably have positive impacts on the lake's water quality and ecosystem in general.

Relatively little erosion and a moderate amount of shoreline alterations were noted during the survey. Only 6% of shoreline parcels showed signs of erosion and few displayed heavy erosion. Approximately 46% of parcels had some type of shoreline alteration, the majority consisting or riprap, which as far as alterations go, is one of the least damaging types in regards to lake ecosystem health. However, almost 30% of noted alterations consisted of seawalls, which are frowned upon by water resource managers due to negative impacts ranging from nearshore habitat loss to ice-induced erosion in neighboring shoreline areas. Although erosion was limited and percentage of alterations somewhat typical for the region, correcting eroded areas, preventing further erosion, and reducing the length of altered shoreline will benefit the Burt Lake ecosystem.

The 2009 survey varied from that of 2001 in that GPS and GIS technologies were incorporated to more accurately track field conditions in relation to parcel delineations. Furthermore, methodologies differed to some extent between the two surveys in terms of parameters surveyed and rating systems. In spite of differences between surveys in methods and technologies employed, comparisons examining change over time are believed to be sufficiently accurate.

Recommendations

The full value of a shoreline survey is only achieved when the information is used to educate riparian property owners about preserving water quality, and to help them rectify any problem situations. The following are recommended follow-up actions:

1. Keep the specific results of the survey confidential (i.e., do not publish a list of sites where *Cladophora* algae were found) as some property owners may be sensitive to publicizing information regarding their property.

2. Send a <u>general</u> summary of the survey results to all shoreline residents, along with a packet of informational brochures produced by the Watershed Council and other organizations to provide information about dangers to the lake ecosystem and public health as a result of poor shoreline property management practices as well as practical, feasible, and effective actions to protect water quality.

3. Organize and sponsor an informational session to present findings of the survey to shoreline residents and provide ideas and options for improving shoreline management practices that would help protect and improve the lake's water quality.

4. Inform owners of properties with *Cladophora* growths of specific results for their property, ask them to fill out a questionnaire in an attempt to interpret causes of the growth, and offer individualized recommendations for water quality protection. Following the questionnaire survey, property owners have the option to contract the Watershed Council to perform site visits and even conduct ground water testing in an effort to gain more insight into the nature of the findings. Again, it should be stressed that all information regarding names, specific locations, and findings be kept

confidential to encourage property owner participation in this project.

5. Inform owners of properties with poor greenbelt scores and those with eroded shorelines of specific results for their property. Supply these property owners with information (e.g., brochures) regarding the benefits of greenbelts and/or the problems associated with erosion. Encourage property owners to improve greenbelts using a mix of native plants and to correct erosion problems. Property owners have the option to contract the Watershed Council to perform site assessments and carry out projects to improve greenbelts and/or correct erosion problems.

6. Take advantage of the internet and the Lake Association's web page to share survey information. A general summary report and this detailed report can be posted on the Association's web page because they do not contain any property-specific information. Property-specific information can be shared via the Association's web page by randomizing and encrypting the shoreline survey database and providing property owners with a code number that refers specifically to survey results from their property. The Watershed Council is available to assist with this approach.

7. Verify links made between shore survey results and land parcel data to ensure that information is being properly reported. Shoreline residents can assist the Watershed Council in determining if house descriptions in survey database match correctly with county land owner information. By doing so, property owners will receive the correct information regarding their parcel. This information is also useful for empowering the lake association to monitor shoreline activities, recruit new members, and compile and manage other water resource information.

8. Repeat some version of the survey periodically (ideally every 3-5 years), coupled with the follow-up activities described previously, in order to promote water quality awareness and good management practices on an ongoing basis. During each subsequent survey, more details about shoreline features are added to the database, which can be utilized for other water resource management applications.

9. Continue to support the Tip of the Mitt Watershed Council Volunteer Lake and Stream Monitoring programs by providing volunteer support. The information collected by volunteers is extremely valuable for evaluating water quality and determining trends. BLPA is encouraged to continue supplying volunteer help and volunteers should attend training sessions held by the Watershed Council to ensure that a complete set of quality data is being collected each year.

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